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Assessing the relationship among Six Sigma, Absorptive Capacity and Innovation Performance

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Abstract

Nowadays in the hypercompetitive marketplace companies try to adopt and apply many strategic approaches and initiatives that have proved its success to improve the competitive advantage, innovative abilities, and business performance in general. Thus, this study attempts to figure out the relationship between Six Sigma and innovation performance, and examine the mediating role of AC in this relationship. A questionnaire was used to collect the data from the manufacturing companies in Malaysia and Partial Least Square (PLS) was adopted to analyze the data obtained. Based on the literature review, the conceptual framework of this study is introduced. The hypotheses were tested and supported through the findings.

Keywords: Six Sigma; Absorptive Capacity; Innovation Performance

1. Introduction

Nowadays in the hypercompetitive marketplace, companies need to maintain and build its competitive advantage. As result, companies try to adopt and apply many strategic approaches and initiatives that have proved its success to improve the competitive advantage, innovative abilities, and business

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performance in general. Innovation has been considered as the vital weapon for sustainable competitive advantage (Cooper, 1998). Based on what has mentioned above, Malaysia is planning to become a developed country by achieving Vision of Malaysia 2020. Innovation-Led Economy is one of many plans that have been conducted with numerous procedures and steps to follow the2020 Vision (10th Malaysia plan 2011-2015, 2010). Although Malaysia has started to concern about innovation since 1990, where it has carried out three waves of survey through its National survey of innovation, the innovativeness of manufacturing companies in Malaysia still low in Malaysia compared to what should have been based on its level of development. This fact represents a main challenging for Malaysian companies to face the global hyper competition whether from the regional peers or from the other countries such as East Europe and South American countries (Tenth Malaysia Plan, 2010).

In this regards, absorptive capacity (AC) has been considered as the key antecedents of innovation performance (Cohen and Levinthal, 1989; 1990; Lane & Koka, 2006). Several studies investigating the nature of AC and its effect on organization have demonstrated that AC has gained a considerable attention of the researchers (Flatten, Engelen, Zahra & Brettel, 2011). AC has been introduced by Cohen and Levinthal (1989, 1990) who argue that AC is one of the capabilities that represent the antecedences which help achieve a superior innovation performance. Based on this theory, considerable research has investigated AC in order to get more insight as to the effect of AC on innovation performance (e.g., Gray, 2006; Liao, Wu, Hu & Tsuei, 2009; Tseng, Pai & Hung, 2011; Yusr, Othman, Mokhtar, 2011). Thus, enhancing AC of the organization is one of the processes that lead to improve the innovative capabilities then sustaining the competitive advantage (Lane & Koka, 2006). So, it is valuable to examine the effect of the organization's strategies on AC to figure out the impact of certain strategies on innovation performance.

Six Sigma is one of successful strategies that has been adopted by many organizations since it was released it in 1980s by Motorola (Abramowich, 2005; Coronado & Antony, 2002). Several studies have been conducted to identify the effect of Six Sigma in reinforcing many organizational aspects (Harry, 1998; Kumar, Antony & Douglas, 2009). However, further research is needed to determine the impact of applying Six Sigma on some important aspects of the organization like innovation performance (Parast, 2010), especially that Six Sigma as quality orientation has became an unavoidable choice to achieve sustainability and the survival of the organization (Hilton, Balla & Sohal, 2008; Kwak & Anbari, 2006).

2. Literature review and hypothesis

2.1. Six Sigma

Six Sigma is defined as a business strategy that aims to enhance business profitability, productivity, customer satisfaction, effectiveness and efficiency of all operations to eliminate the waste to reduce the cost of poor quality for the purpose of meeting or even exceeding customer needs and expectations (Antony & Banuelas, 2002). It is considered as a breakthrough strategy that gathers improved metrics and a latest management philosophy to considerably reduce defects, which is reflected on the advancement of an organizations' market situation and enhances the profit line (Antony & Banuelas, 2002; Black & Revere, 2006; Przekop, 2006). Six Sigma considers defects opportunity as a failure of the process which is critical to customers (Laosirihongthong, Rahman & Saykhun, 2006). At the strategic level, Six Sigma aims to line up the organization keenly to its market and fulfil actual improvement to the bottom line, whereas at the operational level, Six Sigma aims to move business product or service attributes through the area of customer specifications and to shrink process variation (Jr, 1999). The Six Sigma method is also considered as "a project-driven management approach" that improves the organization's product, service, and process with continually reducing defects in the organization, as well as a business strategy which focuses on understanding and developing customers' needs, system of business, productivity and the financial performance (Kawak & Anbari, 2006). Although many studies have examined the effect of Six Sigma on the different issues in the organization, most of those studies focused on particular aspects such as the financial one, satisfaction of the customers, productivity. While some other aspects such as innovation and competitive advantage are somehow ignored or received very little attention.

2.2. *Relationship between Six Sigma and innovation performance*

The relationship between Six Sigma and innovation performance can be traced back to the RBV theory introduced by Wernerfelt (1984) which argues that resource and capabilities of the organization are the antecedences to create competitive advantages and then business performance. Six Sigma as strategy provides several kinds of resources, whether tangible or intangible, which work as complementary sources of innovation and competitive advantage (Pesic, 2007). Although Six Sigma focuses on internal process improvements to achieve the zero-defect target, it insists on understanding the requirements of customers. Hence, companies which apply Six Sigma give attention to the external activities to be in touch with their environment (Lee & Choi, 2006). Parast (2010) argues that since Six Sigma programs translate the voice of customers into independent process improvement projects, thus, it can help to enhance the innovation performance of the organization. Accordingly, the following hypothesis is formulated:

H1: there is a positive relationship between Six Sigma and innovation performance.

2.3. Relationship between AC and innovation performance

AC has been defined as the organizational capability to identify, assimilate, and exploit knowledge from the surrounding environment in the commercial end (Cohen & Levinthal, 1990). The basic concept of the absorptive capacity is that the organization needs previous related knowledge to assimilate and employ new knowledge outside the organization in order to recognize the organizational environment (Cohen & Levinthal, 1990). However, Zahra and George (2002) have refined AC to be four capabilities represented by acquiring, assimilating, transforming and exploiting the knowledge in a unique and distinctive form, and also distinguished between 'potential' and 'realised' absorptive capacity. Potential absorptive capacity makes the organization receptive to acquiring and assimilating external knowledge (Lane & Lubatkin, 1998). This view is compatible with Cohen and Levinthal's (1990) suggestion of an organization's capability to value and acquire external knowledge. Cohen and Levinthal's suggestion, however, does not assure the exploitation of this knowledge. On the other, realized absorptive capacity is a function of the transformation and exploitation capabilities, where it reflects the organization's capacity to leverage the knowledge that has been absorbed. These capabilities have been considered as critical capabilities to the companies that tend to compete through innovation (Cohen and Levinthal, 1990).

Given the fact that knowledge is important to the innovation process, absorptive capacity represents a vital part of an organization's ability to create new knowledge (Cohen and Levinthal, 1989). Maintaining or developing the absorptive capacity of an organization would incur research and development (R&D) expenditure, and the AC influences innovation performance positively (Liao *et al.,* 2009). Cohen and Levinthal (1990) refer to knowledge as an essential source of innovation, specifically the external knowledge. According to Jantunen (2005), majority of the studies in the innovation literature confirmed the substantial role of capacity in using external knowledge, that is, absorptive capacity influenced innovation. Based on the discussion above, the following hypothesis is introduced:

H2: there is a positive relationship between AC and innovation performance

2.4. Relationship between Six Sigma and AC

According to Cohen and Levinthal (1990) argument, problem solving and learning capabilities are the antecedents of AC. learning capabilities involve the development of the capacity to assimilate existing knowledge, while problem solving skills represent a capacity to create new knowledge. Based on the psychologists' suggestion, Cohen and Levinthal (1990) elucidate the role of prior knowledge in enhancing the learning process and problem-solving skills in the individual level to deal with advanced methods in the specific area. Moreover, Cohen and Levinthal also confirm that learning capabilities include the development of capacity to comprehend the existing knowledge (for imitation), whereas problem solving skills represent an ability to generate new knowledge (for innovation). Kim (1998) agrees with this orientation by considering organizational learning and developing problem-solving skills as the requirements of organization's absorptive capacity.

Applying Six Sigma in the organization needs many requirements known to be critical success factors of implementing Six Sigma such as special structure, tools, programs, and like (Antony & Banuelas , 2002; Coronado & Antony, 2002). Adopting and implementing those requirements to apply Six Sigma successfully help to enhance the learning abilities of the organization and also improve and build the problem-solving skills among the employees, which have been considered as the main requirements of AC to create knowledge whether for innovation or imitation (Yusr *et al.,* 2011). Choo, Linderman & Schroeder (2007) state that Six Sigma project include specific problem-solving steps with recommended statistical and non statistical tools in each steps. Snee (2000) has also considered Six Sigma as the technique that sequences and links betterment tools into aggregate approach. Utilizing this structure method is the main components in Six Sigma that can provide a systematic approach to learning and creating knowledge. According to Choo *et al.* (2007), increasing the opportunities to identify and define the problem earlier provides great opportunities to learning and improvement tend to follow. To sum up, applying Six Sigma successfully in the organizations provides the infrastructure that allows the process of evaluating, assimilating, integrating, and using knowledge in a particular method (Bosch, Volberda & Boer, 1999). Therefore, building on the discussion above, the following hypothesis is proposed:

H3: there is positive relationship between Six Sigma and AC.

According to the previous discussion, it can be argued that AC represents the mediating variable in the relationship between Six Sigma and innovation performance. Thus, the following hypothesis is formulated:

H4: AC mediates the relationship between Six Sigma and innovation performance.

3.Research Design

3.1. Data Collection and Demographic Distribution of the Sample

This study used online survey to collect the necessary data from the manufacturing organizations in Malaysia which applied Six Sigma. The unit of analysis was the managers of the quality or managers of R&D, or operation managers. Out of 80 questionnaires that have been sent to the 80 companies, 65 questionnaires were responded to. Since the online questionnaire was structured in a way that the respondent would not be able to submit it if it included any missing data, there was no missing values. All the constructs were measured using 7-point likert scales (from strongly disagree =1 to strongly agree =7). The questionnaire contains four parts: A) demographic data, B) to measure Six Sigma, C) to measure AC, and finally, D) to measure innovation performance.

3.2 Data Analysis and Hypotheses Test Results

Due to the small sample size of this study, Partial Least Square (PLS) path modelling algorithm was employed. PLS is far less restrictive in its distributional assumptions and sample size restrictions as compared to covariance-based structural equation modelling (Chin, 1998). PLS is applied to situations where knowledge about distribution of the latent variables is limited, and it requires the estimates to be more closely tied to the data compared to covariance structure analysis (Fornell & Cha, 1994). Henseler, Ringle, and Sinkovics (2009) recommend that the PLS model should be analyzed and interpreted in two stages: the measurement model and the structural model. Moreover, in case the model includes second and first order measurement, then the analysis to confirm the reliability and validity of the measurement model should be done in two steps: first order and second order. By using SmartPLS version 2.0.M3 the following result came out.

3.3. Measurement model

PLS assesses the reliability of individual item by examining the loadings of respective items on their respective latent construct (Hulland, 1999). According to Hair, Black, Babin and Anderson (2010), and Chin (1998), factor loading of the items can be employed to confirm the content validity of the measurement model. That is, all the items aiming to measure a specific construct should load highly on the construct those items were designed to measure. In addition, to assess the degree to which a group of variables converge in measuring the concept on construct, the convergent validity was evaluated through using items reliability ($\alpha > 0.7$) , composite reliability ($\rho_c > 0.7$) and average variance extracted (AVE > 0.5) (Hair *et al*., 2010; Henseler *et al.,* 2009). Discriminant validity of measurement model was tested through Fornell and Larcker's (1981) AVE test and cross loadings criterion. Discriminant validity of has been confirmed, where the value of square root of the AVE exceeds the correlations between the factors making each pair (Fornell and Larcker, 1981). As shown in the following Tables and Figure.

Figure 1: The structural model

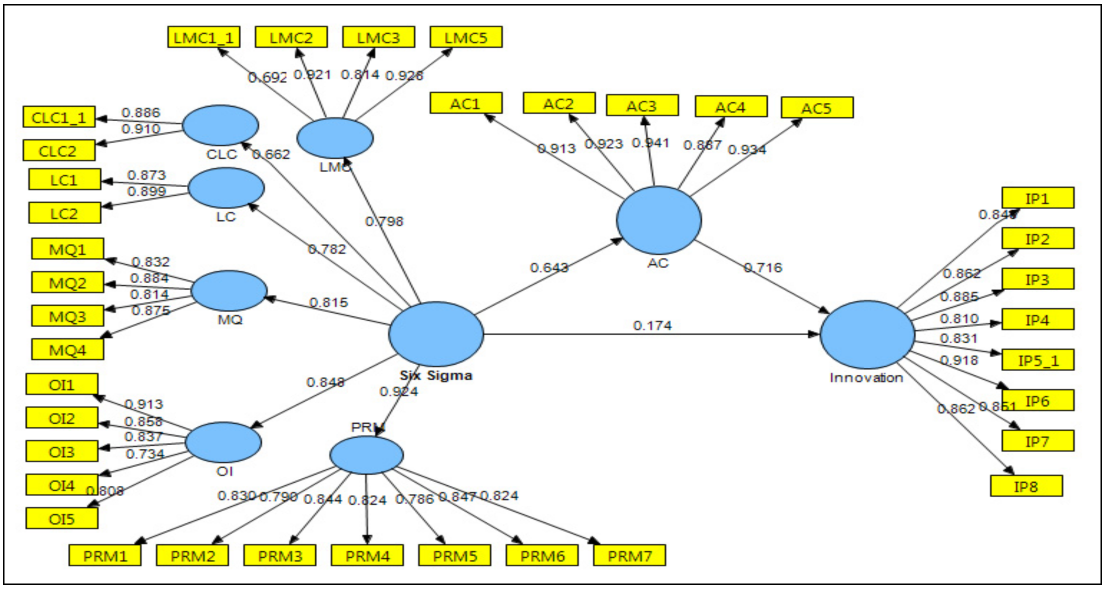

Table 1: Validity and reliability of the measurement mode

Construct	Items	Internal reliability	Convergent validity		
		Cronbach's alpha	Factor Loading	Composite reliability	AVE
Six Sigma	CLC	0.954	0.898	0.959	0.495
	LC		0.886		
	LMC		0.839		
	MQ		0.851		
	OI		0.830		
	PRM		0.821		
AC	AC1	0.954	0.913	0.965	0.846
	AC2		0.923		
	AC3		0.941		
	AC4		0.887		
	AC5		0.934		
IP	IP1	0.949	0.848	0.957	0.737
	IP2		0.862		
	IP3		0.885		
	IP4		0.810		
	IP5		0.831		
	IP6		0.918		
	IP7		0.851		
	IP8		0.862		

Table 2: Cross loading of the items

Construct	AC	IP	Six Sigma
AC1	**0.913**	0.742	0.553
AC2	**0.923**	0.777	0.609
AC3	**0.941**	0.810	0.655
AC4	**0.887**	0.732	0.577
AC5	**0.934**	0.744	0.557
IP1	0.714	**0.848**	0.481
IP2	0.653	**0.862**	0.528
IP3	0.735	**0.885**	0.532
IP4	0.585	**0.810**	0.423
IP5	0.751	**0.831**	0.499
IP6	0.746	**0.918**	0.625
IP7	0.757	**0.851**	0.639
IP8	0.722	**0.862**	0.604
CLC	0.276	0.318	**0.898**
LC	0.428	0.360	**0.886**
LMC	0.383	0.484	**0.839**
MQ	0.470	0.440	**0.851**
OI	0.550	0.421	**0.830**
PRM	0.506	0.469	**0.821**

Table 3: The correlation among the construct and discriminant validity

Construct	Square root of AVE	CLC	LC	LMC	MQ	OI	PRM
CLC	0.898	1					
LC	0.886	0.576	1				
LMC	0.844	0.618	0.629	1			
MQ	0.852	0.522	0.521	0.587	1		
OI	0.832	0.446	0.579	0.564	0.604	1	
PRM	0.821	0.486	0.709	0.625	0.699	0.760	1

3.4 Structural Model and Hypothesis Testing

The relationship among the variables has been tested through running PLS algorithm and Bootstrapping algorithm in SmartPLS 2.0.

Table 4: The path coefficient

Construct	Path Coefficient	standard Error	T-value	P-value	Result
H1:Six Sigma -> innovation (direct relationship)	0.653***	0.0742	8.800	0.000	Supported
H2:AC -> Innovation	0.716***	0.086	8.328	0.000	Supported
H3: Six Sigma -> AC	0.643***	0.093	6.910	0.000	Supported
H4: Six Sigma -> AC -> innovation performance	0.461***	0.094	4.903	0.000	Supported
Six Sigma -> Innovation (when AC is introduced)	0.174	0.109	1.603	0.054	Not supported

*** $P<0.001$

Table 4shows that all the hypotheses have been supported. However, the value of direct relationship between Six Sigma and innovation performance is retreated because of the effect of the mediating variable AC. Furthermore, the variance accounted for (VAF) indicates that 73% of the effect of Six Sigma on innovation comes through the mediating variable AC. Therefore, AC is established as a full mediator in this relationship.

4. Discussion and conclusions

Based on the review of the related literature, the current framework was introduced. Through this framework, the current study somehow attempts to reduce the gap as to the relationship between Six Sigma and innovation performance. Furthermore, the present study aims to provide some insight regarding this relationship through examining the mediating role of AC in the relationship between Six Sigma and innovation performance. The findings of the analysis show that Six Sigma has a significant and positive influence AC ($\beta=0.643$, $t=6.910$, $p<0.001$). Also, the results indicate that AC positively affects innovation performance ($\beta=0.716$, $t=8.328$, $p<0.001$). The mediating effect of AC has also been proved by the findings of this study, where 73% of the effect of Six Sigma on innovation performance is explained trough AC. However, the direct relationship between Six Sigma and innovation performance was substantially reduced to be insignificant when the mediating relationship was introduced, which refers to the full mediating effect of AC in the relationship between Six Sigma and innovation. Therefore, it can be concluded that AC as capabilities are very crucial to enhance and develop innovation performance. Hence, companies which tend to be innovative are recommended to build its absorptive capabilities as the basis or first step towards innovation. Further studies should be done to determine the factors that affect on AC in order to get more understanding regarding how to improve the absorptive capabilities in the organization level.

5. Managerial Implications

The implications of this study are represented in several aspects. First, this study provides the evidence that AC represents the critical antecedents of innovation performance. Moreover, it justifies the tendency to apply and adopt Six Sigma to enhance not only the financial aspect of performance but also the innovation performance of the companies. Additionally, it can be concluded from the findings of this study that Six Sigma as a strategy also contributes to enhancing some capabilities related to innovation like AC. Finally, this research helps the managers of the manufacturing companies to determine the most important capabilities that should be focused on to achieve the desired innovation performance.

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